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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Earth and the like Boring or Drilling Apparatus

We, ENGLISH DRILLING EQUIPMENT COMPANY LIMITED, a British Company, and FRANK WALMSLEY a British subject, both of the Company's address of Palace Chambers, Bridge Street, Westminster, London, S.W.1., do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

THIS INVENTION relates to boring or drilling apparatus used for earth, rock and like boring or drilling operations.

In such apparatus a drill bit or cutting tool is carried at one end of a "string" of drill rods which receive and transmit to said bit or tool a rotary and feed motion from a suitable source. With such apparatus it is known to give simultaneously with the rotary and feed motion for cutting purposes a percussive action to the drill bit or tool, particularly when, for example, hard strata is being bored. It is an object of the present invention to give a percussive action to the drill bit or tool by means which, though simple in construction, is efficient in operation.

According to the invention apparatus for applying percussive blows to the drill bit of boring or drilling apparatus comprises a cylinder member adapted for connection to the drill rod string, a hammer like piston member operating in said cylinder member, inlet and exhaust ports in the cylinder wall for passage of a pressurized gaseous medium, and passage means in said piston member for controlling passage of said gaseous medium to and from said cylinder member through said inlet and exhaust ports respectively, the opening and closing of said ports being controlled by said piston member during movement of the latter by the gaseous medium in a manner whereby the hammer like piston

member provides percussive blows for the drill bit.

In one form of the invention the cylinder member is adapted for connection to the last drill rod at the outer or lower end of the drill rod string, and an extension of the drill bit is carried by and movable relative to the outer or lower end of the cylinder member, a projecting or tail portion of the piston member applying the percussive blows to the drill bit extension. In this form the cylinder member may comprise inner and outer tubular members spaced apart to form an annular chamber divided into compressed air supply and exhaust sections, the inlet and exhaust ports being formed in the inner tubular member and opening into said supply and exhaust sections of the annular chamber respectively. The compressed air can be conveniently supplied through the usual bore of the drill rod string to passage means formed in a cylinder head and leading to the supply section of the annular chamber.

In another form of the invention one end of the cylinder member is connected to one part of a two-part telescoping unit, the other part of which is adapted for connection to the first drill rod of the drill rod string, and the other end of the cylinder is connected to a driving quill providing the rotary and feed motion to the drill rod string, the hammer like piston member applying the percussive blows to an extension or stem portion of said other part of the two part telescoping unit and thus through the drill rod string to the drill bit. In this form of the invention, the cylinder member rotates within a non-rotary air swivel assembly comprising a sleeve member surrounding and spaced from the cylinder members to form an annular chamber divided into a compressed air supply section and an air exhaust section into which the inlet and ex-

[Price 4s. 6d.]

haust ports of the cylinder member open respectively.

Suitable constructions of both of the above referred to forms of the invention are described by way of example in what follows, and are illustrated in the accompanying drawings in which:

Fig. 1 is a longitudinal sectional view of a vertical boring or drilling type of apparatus constructed according to the invention, whilst

Fig. 2 is a detail thereof to be referred to later,

Fig. 3 is a view similar to Fig. 1 but showing a modified form of the cylinder and piston members, whilst

Fig. 4 is a detail to be referred to later,

Fig. 5 is a longitudinal sectional view of another form of apparatus which is particularly adapted for boring or drilling horizontally, or inclined thereto, whilst

Fig. 6 is an external view at right angles thereto.

As shown in Figs. 1 and 2 the cylinder member is indicated generally at a and is provided with a cylinder head b spaced from a drill rod connector c by a cushion assembly d . The latter comprises an inner member d' screw-threaded into head b , and an outer sleeve d'' which is splined or keyed to d' and also screw-threaded into rod connector c . This drill rod connector c is screw-threaded at its outer reduced end at c' for connection to the last drill rod (not shown) forming the outer end of the drill rod string.

The cylinder member a comprises an outer tube a' and an inner liner tube a'' , the tube a' being internally threaded at its upper ends for connection to the cylinder head b . The upper end of the liner tube a'' of the cylinder member has a forced fit and sealed connection to the lower end of the cylinder head b which is reduced to a diameter such that the tubes a' and a'' are spaced apart to form an annular chamber between them. For the purpose of dividing this annular chamber into two sections e and e' the liner tube a'' is formed with a suitably positioned enlarged or divider portion a'' of an external diameter which closely fits the internal diameter of tube a' . Sealing rings, which may be of any suitable form or material, are indicated at a'' for sealing sections e and e' of the annular chamber from each other. Fig. 2 shows clearly the construction of the liner tube a'' so far described.

The lower end of the outer tube a' of the cylinder member is internally threaded for connection to a drill bit guide member f , the upper end of which also has a forced fit and sealed connection to the lower end of the liner tube a'' . The drill bit, indicated at g , has its shank g' slidably received within a central bore of the bit guide f , the shank g' and guide bore being correspondingly splined as

indicated at h for transmission of rotary motion from the bit guide to the drill bit. One side of the shank g' is also slotted at i to receive a pin j passing transversely through the bit guide f , the length of the slot being such as to permit a limited freedom of movement of the drill bit shank within and relative to the drill bit guide f .

Within the bore of the liner tube a' of the cylinder member a , between the cylinder head b and the drill bit guide f , there is operably located a hammer like piston member k for the purpose of giving rapid successive percussive blows to the drill bit g . The cylindrical surface of the piston k has two spaced apart circumferential grooves forming an upper groove k' and a lower groove k'' . The upper groove k' is connected by an inclined passage or bore m to the cylinder space n located beneath the piston and above the drill bit guide f . In a similar manner the lower groove k'' is connected by an inclined passage or bore o to the cylinder space p located above the piston and below the cylinder head b . The piston k has a projecting portion or tail q by means of which percussive blows developed by the piston can be transmitted to the end of the shank of the drill bit g .

In the liner tube a' of the cylinder member a there are formed compressed air inlet ports or passages r and air exhaust ports s . These inlet and exhaust ports are located at opposite sides of the divider portion a'' of liner tube a' (see Fig. 2), and are so positioned and spaced apart in the tube a' such that they can co-operate in sequence with the spaced apart grooves k' and k'' of the piston k for effecting entry of compressed air into and exhaust from the cylinder spaces n and p . Compressed air for operating piston k is supplied by the boring plant compressor and passed through the bore of the hollow drill rod string from which it enters the bore c' of the drill rod connector c and passes through the bore of the cushion assembly d to a chamber b' in the cylinder head b . A series of inclined passages b'' in the cylinder head lead the compressed air from chamber b' to section e of the annular chamber in the cylinder member. The lower end of section e' of the annular chamber in the cylinder member is open for passage of exhaust air therefrom to a passage or passages such as f' in the drill guide f , from which the air passes to the drill bit and borehole for cooling the bit and removing cuttings.

With the arrangement above described and the piston k and drill bit g in the position illustrated in Fig. 1, compressed air supplied to the drill rod string will pass through the bore of the drill rod connector c and cushion assembly d to the cylinder head chamber b' and passages b'' and enter section e of the cylinder chamber. From the latter the compressed air passes through the inlet ports r

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to the upper piston k , the cylinder resultant underside moves up a short distance d is cut off covered piston becomes k' and k'' exhaust piston or sleeve k' , and the cylinder piston up such k' passes thus the lower chamber sages f in such upward direction the inlet passed by cylinder trapped exerts a downward it has inlet and exhaust piston烂 by stopping the cylinder passage of the piston this position in the cylinder and apply its drill bit guide f . of the piston k' comes exhaust port cylinder through the annular passages f piston has again in a and thus repeatedly hammer like the supply rod string

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to the upper circumferential groove k^1 of the piston k , and is lead by the piston bore m to the cylinder space n beneath the piston. The resultant force of the compressed air on the underside of the piston causes the latter to move upward, and after the piston has moved a short distance the supply of compressed air is cut off by reason of the inlet ports r being covered by the portion or land k^2 of the piston between its upper and lower grooves k^1 and k^2 . In this position of the piston the exhaust ports s are also closed by an extension or skirt k^4 of the piston below its groove k^3 , and the entrapped compressed air in the cylinder space n expands and drives the piston upwards to the top of its stroke. During such upward movement of the piston skirt k^4 passes clear of the exhaust ports s , and thus the air in the cylinder space n is passed to exhaust through section e^1 of the annular chamber in the cylinder member, and the passages f in the drill bit guide. Also during such upward movement of the piston its lower circumferential groove k^2 coincides with the inlet ports r , and thus compressed air is passed by way of the piston bore o to the cylinder space p above the piston. This entrapped compressed air above the piston exerts a force on the latter thereby causing downward movement of the piston, and after it has moved down a short distance the inlet and exhaust ports r and s are cut off by the piston land k^3 and skirt k^4 respectively, thereby stopping the supply of compressed air to the cylinder space p above the piston and the passage of air from the cylinder space n below the piston through the exhaust ports s . In this position of the piston the entrapped air in the cylinder space p above the piston expands and forces the piston downwards to apply its hammer or percussive blow to the drill bit g which is slidably movable in its guide f . During this downward movement of the piston its lower circumferential groove k^2 comes in line with and uncovers the exhaust ports s , thus allowing the air in the cylinder space p above the piston to pass through the piston bore o to exhaust via the annular cylinder chamber section e^1 and the passages f in the drill bit guide. When the piston has applied its percussive blow it is again in a position to repeat the above cycle, and thus rapid percussive blows are repeatedly and automatically given by the hammer like piston to the drill bit so long as the supply of compressed air through the drill rod string is continued.

The form of apparatus illustrated in Figs. 3 and 4 is similar to that of Figs. 1 and 2, and differs only in the construction of the cylinder liner tube a^1 of Fig. 1 and the piston member operating therein. The references used in Figs. 1 and 2 have been used for similar parts in Figs. 3 and 4. In Figs. 3 and 4, as in Figs. 1 and 2, the cylinder member a

comprises an outer tube a^1 and a liner tube a^2 spaced apart to form an annular chamber between them. For the purpose of dividing the annular chamber into two sections e and e^1 the liner tube a^2 is formed with a suitably positioned enlarged or divider portion a^3 of an external diameter which closely fits the internal diameter of tube a^1 . As will be apparent from a comparison of Figs. 2 and 4, this divider portion a^3 differs from the enlarged portion a^3 of Fig. 2 in that it is of greater length to accommodate two pairs of diametrically opposed cut-away portions t and u . These cut-away portions are of semi-elliptical or like form and each pair projects longitudinally, and in opposed directions commencing from opposite ends, of the divider portion a^3 . Adjacent the extremities of the major axes of these cut-away portions there are located ports leading to the interior of liner tube a^2 , a pair of inlet ports v for the cut-away portions t and a pair of exhaust ports w for the cut-away portions u . A sealing member, which may be of any suitable material, is indicated at a^4 for sealing sections e and e^1 of the annular chamber from each other. This sealing member is seated in the divider portion a^3 and is of endless form as it passes between the cut-away portions t and u and around the ends thereof. By this construction of divider portion a^3 the positions of the ports v and w in liner tube a^2 are reversed relative to the positions of the ports r and s in the Fig. 1 construction, that is the inlet port v is now below the exhaust port w .

The construction of the piston k of Fig. 3 is similar to that of Fig. 1 in that it has the spaced apart upper and lower circumferential grooves k^1 and k^2 respectively and their associated bores m and o . Because of the reversal in position of the ports v and w , however, a skirt k^4 is provided above groove k^1 and not below groove k^2 . With this construction of Figs. 3 and 4, and piston k in the position shown in Fig. 3, compressed air supplied to section e of the cylinder chamber will pass into the grooves t of divider a^3 and through inlet ports v , groove k^1 and bore m to cylinder space n beneath the piston and raise the latter. After the piston has moved a short distance the supply of compressed air is cut off by reason of the land k^3 covering the inlet ports v . In this position the exhaust ports w are also closed by the skirt k^4 , and the entrapped compressed air in the cylinder space n expands and drives the piston to the top of its stroke. During such upward movement of the piston the upper circumferential groove k^1 coincides with exhaust ports w and thus the air in cylinder space n is passed to exhaust by way of bore m , ports w and cut-away portions u . Also during such upward movement of the piston the lower circumferential groove k^2 coincides with

inlet ports *v* and thus compressed air is passed by way of bore *o* to cylinder space *p* above the piston to cause downward movement of the latter. After the piston has moved down a short distance the inlet and exhaust ports *v* and *w* are cut off by the land *k*³ and skirt *k*³ respectively, thereby stopping supply of compressed air to the cylinder space *p* and the passage of air from cylinder space *n* to exhaust through ports *w*. In this position the entrapped air in cylinder space *p* expands and forces the piston downwards to apply its hammer blow to the drill bit *g*. During the downward movement of the piston the skirt *k*³ uncovers exhaust ports *w* to allow the air in cylinder space *p* to pass to exhaust. When the piston has applied its percussive blow it is again in a position to repeat the above cycle.

In the form of the invention illustrated in Figs. 5 and 6 the cylinder member 2 is adapted for convection to a driving quill 3 by means of an adaptor plate 4. The latter is secured by screws 5 to a flange 6 formed on one end of cylinder 2, and by screws 8 to the quill flange 9. The quill 3 receives a rotary and feed motion for transmission to the drill rod string, and this may be provided in any known manner, such as for example by a rotary drill head supported by a carriage which is movable along a base frame to provide the feed motion. A portion of such a carriage, to be referred to later, is indicated at 10. The other, outer, end of cylinder 2 is adapted for connection to the first drill rod of the drill rod string by means of a two-part telescoping unit, one part 11 of which has a flange 12 secured by screws 13 to the outer end of cylinder 2. The other telescoping part of the telescoping unit has a central portion 14 slidable within a bore of part 11 and an extension or stem 15 provided at its outer end with a tapered screw thread 16 for receiving the correspondingly screw-threaded end of the first drill rod (not shown) of the drill rod string. A further extension or stem 17 of the telescoping part 11 projects within cylinder 12 and is splined or keyed at 18 to part 11 of the telescoping unit so that it can receive the rotary motion of the cylinder 2 provided by quill 3.

Within the bore of cylinder 2 there is operably located a hammer like piston member 19 for giving rapid successive percussive blows to the drill bit through the intermediary of the telescoping or sliding part of the telescoping unit and its attached drill rod string, to the outer end of which the drill bit is secured. The cylindrical surface of the piston 19 has two spaced apart circumferential grooves 20 and 21, the former of which is connected by radial and longitudinal bores 22 in the piston to a cylinder space 23 located between one end of the piston and one end of the telescoping unit. The groove 21

is connected by radial and longitudinal bores 24 in the piston to a cylinder space 25 located between the other end of the piston and the cylinder adaptor plate 4.

In the wall of the cylinder 2 there are formed compressed air inlet ports 26 and air exhaust ports 27 which are so positioned and spaced apart in the cylinder wall such that they can co-operate in sequence with the spaced apart grooves 20 and 21 of the piston 19 for effecting entry of compressed air and exhaust from the cylinder spaces 23 and 25. For supply and exhaust of compressed air a non-rotatory air swivel assembly is provided consisting of a sleeve 28 surrounding and spaced from the cylinder wall to form an annular chamber divided by an oil seal 29 into a compressed air supply section 30 and an air exhaust section 31. The inlet ports 26 in the cylinder wall open into compressed air supply section 30, while the exhaust ports 27 open into air exhaust section 31. Bushings 32 at each end of the sleeve 28 provide bearings for rotation of cylinder 2 within the sleeve, and further oil seals 33 serve to seal these bearings against escape of air from the sleeve sections 30 and 31. Compressed air for operating piston 19 is supplied by the boring plant compressor and passed to a compressed air inlet connection 34 provided upon sleeve 28 leading to compressed air supply section 30 of the sleeve. An air exhaust connection for exhaust section 31 of the sleeve is indicated at 35. Sleeve 28 may be prevented from rotation in any suitable manner, and for the purpose of illustration is shown provided with a boss 36 supporting a steady or guide pin 37. The latter contacts a guide 38 mounted upon the carriage 10 which supports a rotary drill head previously referred to.

The operation of the apparatus of Figs. 5 and 6 is similar to that of the apparatus of Figs. 3 and 4, compressed air supplied to section 30 of the sleeve passing through inlet ports 26, groove 20 and bores 22 to cylinder space 23 to move the piston 19 in a direction towards adaptor plate 4, to a position in which the land 39 of the piston cuts off the compressed air supply from inlet ports 26. In this position the entrapped compressed air in cylinder space 23 expands and drives the piston to a further position in which piston groove 20 coincides with exhaust ports 27 to exhaust cylinder space 23. Further, in this piston position piston groove 21 coincides with inlet ports 26 to pass compressed air via bores 24 to cylinder space 25 to move piston 19 in a reverse direction to a position in which piston land 39 cuts off compressed air supply from inlet ports 26. Consequently the entrapped air in cylinder space 25 expands and moves the piston with a force to apply its hammer blow to extension 17 of telescopic part 11 and thus through the drill

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WHAT 1. App: to the dri drilling member : rod string operating exhaust f sage of a passage r controlling to and fr said inlet opening a trolled by ment of t a manner member 1 drill bit.

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3. Appa 2, having ber servir compresse cylinder s member, member s air to a c end of the latter cyli skirt on sa ber.

4. App: claim, wi adapted fo the outer and an ex and mova end of the tail portio the percus

tal and longitudinal bores a cylinder space 25 located end of the piston and the ate 4. 70
the cylinder 2 there are air inlet ports 26 and air hich are so positioned and e cylinder wall such that te in sequence with the es 20 and 21 of the piston try of compressed air and cylinder spaces 23 and 25. haust of compressed air a vival assembly is provided eeve 28 surrounding and cylinder wall to form an dived by an oil seal 29 air supply section 30 and tion 31. The inlet ports wall open into compressed 30, while the exhaust ports exhaust section 31. Bush-d of the sleeve 28 provide in of cylinder 2 within the oil seals 33 serve to seal nst escape of air from the and 31. Compressed air on 19 is supplied by the essor and passed to a connection 34 provided upon to compressed air supply leeve. An air exhaust con- section 31 of the sleeve is
Sleeve 28 may be pre- on in any suitable manner, se of illustration is shown oss 36 supporting a steady The latter contacts a guide the carriage 10 which sup- head previously referred

if the apparatus of Figs. 5 o that of the apparatus of compressed air supplied to sleeve passing through inlet 0 and bores 22 to cylinder the piston 19 in a direction plate 4, to a position in of the piston cuts off the y from inlet ports 26. In ntrapped compressed air in expands and drives the r position in which piston s with exhaust ports 27 to pace 23. Further, in this iston groove 21 coincides to pass compressed air via er space 25 to move piston direction to a position in 39 cuts off compressed air ports 26. Consequently in cylinder space 25 ex- the piston with a force to blow to extension 17 of and thus through the drill

rod string to the drill bit. As the piston moves to apply its hammer blow a skirt 40 on the piston uncovers exhaust ports 27 to exhaust cylinder space 25. When the piston has applied its percussive blow it is again in position to repeat the above cycle. 70

It will be appreciated from the above that by the invention a simple form of apparatus for applying percussive blows to the drill bit of earth or like boring or drilling mechanism is provided which has a minimum of moving parts, no moving valves being necessary but instead only ports covered or exposed by the hammer like piston. Further, the apparatus will function at all angles of use, including vertically upwards, and is easily dismantled for examination and replacement of worn or defective parts. 75

WHAT WE CLAIM IS:—

1. Apparatus for applying percussive blows to the drill bit of earth and the like boring or drilling apparatus comprising a cylinder member adapted for connection to the drill rod string, a hammer like piston member operating in said cylinder member, inlet and exhaust ports in the cylinder wall for passage of a pressurized gaseous medium, and passage means in said piston member for controlling passage of said gaseous medium to and from said cylinder member through said inlet and exhaust ports respectively, the opening and closing of said ports being controlled by said piston member during movement of the latter by the gaseous medium in a manner whereby the hammer like piston member provides percussive blows for the drill bit. 80
2. Apparatus according to claim 1 having means mounted on the cylinder member for movement relative thereto, said means receiving the percussive blows of the piston member and transmitting the same directly, or indirectly through the drill rod string, to the drill bit. 85
3. Apparatus according to claim 1 or claim 2, having passage means in the piston member serving for both inlet and exhaust of compressed air to and from respectively a cylinder space adjacent one end of the piston member, and passage means in the piston member serving only for inlet of compressed air to a cylinder space adjacent the opposite end of the piston member, exhaust from the latter cylinder space being controlled by a skirt on said opposite end of the piston member. 90
4. Apparatus according to any preceding claim, wherein the cylinder member is adapted for connection to the last drill rod at the outer or lower end of the drill rod string, and an extension of the drill bit is carried by and movable relative to the outer or lower end of the cylinder member, a projecting or tail portion of the piston member applying the percussive blows to the drill bit extension. 95

5. Apparatus according to any preceding claim, wherein the cylinder member comprises inner and outer tubular members spaced apart to form an annular chamber divided into compressed air supply and exhaust sections, the inlet and exhaust ports being formed in the inner tubular member and opening into said supply and exhaust sections of the annular chamber respectively, the compressed air being supplied through a bore of the drill rod string to passage means formed in a cylinder head and leading to the supply section of the annular chamber. 100

6. Apparatus according to claim 5, wherein the annular chamber of the cylinder is divided into said sections by a divider member formed upon or integral with the inner tubular member and of a diameter fitting the internal diameter of the outer tubular member, said divider member being positioned between the inlet and exhaust ports and having sealings rings for sealing said sections of the annular chamber from each other. 105

7. Apparatus according to claim 5, having the annular chamber of the cylinder divided into said sections by a divider member formed upon or integral with the inner tubular member and of a diameter fitting the internal diameter of the outer tubular member, diametrically opposed cut-away portions projecting longitudinally, and in opposed directions commencing from opposite ends, of said divider member, inlet and outlet ports located in the cut-away portions and leading to the compressed air supply and exhaust sections respectively of said annular chamber and sealing means seated in the divider member and of endless form as it passes between the cut-away portions and around ends thereof. 110

8. Apparatus according to claim 5 or claim 6, having the cylindrical surface of the piston member formed with two spaced apart circumferential grooves, passage means in the piston member connecting one groove to a cylinder space located at one end of said member, passages means in the piston member connecting the other groove to a cylinder space located at the other end of said member, a skirt at one end of the piston member and a projecting portion or tail projecting from said skirt for applying to the drill bit the hammer blows developed by the piston member. 115

9. Apparatus according to claim 5 or claim 7, having the cylindrical surface of the piston member formed with two spaced apart circumferential grooves, passage means in the piston member connecting one groove to a cylinder space located at one end of said member, passage means in the piston member connecting the other groove to cylinder space located at the other end of said member, a skirt at one end of the piston member and a projecting portion or tail projecting from the other end of the piston member for apply- 120

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ing to the drill bit the hammer blows developed by the piston member.

10. Apparatus according to any one of the preceding claims 5 to 9, having outer ends of the inner and outer tubular members secured to a drill bit guide, a central bore within said guide for slidably receiving an extension or shank of the drill bit, said shank being keyed or splined within said bore for transmission of rotary motion from the bit guide to the drill bit, and pin and slot means in said guide and shank for permitting limited sliding movement of the shank within the guide.

15. 11. Apparatus according to any one of the preceding claims 1 to 3, wherein one end of the cylinder member is connected to one part of a two-part telescoping unit, the other part of which is adapted for connection to the first 20 drill rod of the drill rod string, and the other end of the cylinder is connected to a driving quill providing the rotary and feed motion to the drill rod string, the hammer like piston member applying the percussive blows to an extension or stem portion of said 25 other part of the two-part telescoping unit and thus through the drill rod string to the drill bit.

12. Apparatus according to claim 11, 30 wherein the cylinder member rotates within a non-rotatory air swivel assembly comprising

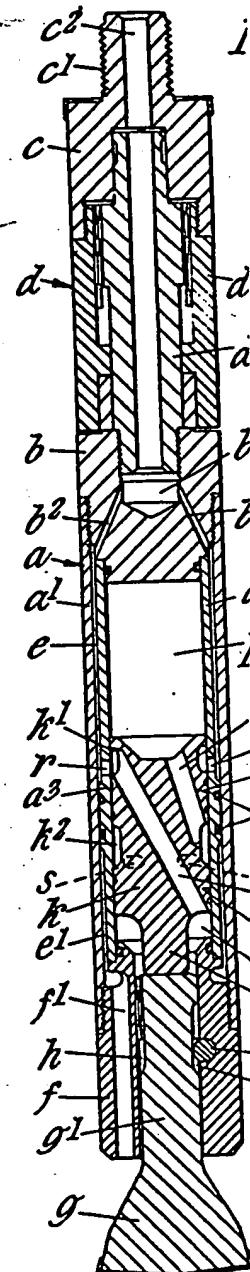
a sleeve member surrounding and spaced from the cylinder member to form an annular chamber divided into a compressed air supply section and an air exhaust section into which the inlet and exhaust ports of the cylinder member open respectively.

13. Apparatus according to claim 11 or claim 12, having the cylindrical surface of the piston member formed with two spaced apart circumferential grooves, passage means in the piston member connecting one groove to a cylinder space located at one end of said member, passage means in the piston member connecting the other groove to a cylinder space located at the other end of said member, and a skirt at one end of the piston member the other end of which applies the percussive blows to the extension or stem portion of said other part of the two part telescoping unit and thus through the drill rod string to the drill bit.

14. Apparatus for applying percussive blows to the drill bit of earth and the like boring or drilling apparatus substantially as described with reference to the Figures 1 and 2, or Figs. 3 and 4 or Figs. 5 and 6 of the accompanying draws.

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Agents for the Applicant(s).

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